

REMARKS

These remarks are submitted in response to the Final Office Action mailed August 4, 2004, and the Advisory Action mailed October 28, 2004. A listing of claims is provided for the Examiner's convenience. No claims have been amended hereby.

In paragraphs 1-38 of the Office Action, claims 1-2, 4-5, 8-9, 12-13, 15-16 and 18-20 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,176,453 to Long et al. (Long) in view of European Patent Application Publication No. EP 0919647A1 to NEC Corporation (Okamoto). Applicants respectfully traverse these rejections.

Applicants renew their assertion that the limitations of independent claims 1 and 13 are neither taught nor suggested in the prior art of record. In particular, these claims require a composite material heat controller having a phase-change substance overlying a base material, "wherein said phase-change substance comprises a thickness in the range of about 1 to about 30 microns." With the claimed phase-change substance thickness, a simple configuration composite heat controller is formed having a light-weight and a broad range of applications with an enhanced degree of freedom (flexibility). See Specification page 7, lines 3-21. Applicant's hereby incorporate by reference those arguments made in the remarks of their Response to Final Office Action.

As stated in the prior Response, both Okamoto and the instant application control the heat in a space vehicle, and thus are in the same field. As in any space vehicle application, Okamoto was motivated to reduce the thickness of its film and thereby reduce the weight. Yet Okamoto teaches that the phase-change layer should be several hundred microns thick. This teaching of Okamoto actually shows a lack of motivation rather than a motivation to reduce the thickness of the phase-change layer as suggested in the Office Action.

Page 4 of the Advisory Action characterizes Applicant's argument as "flawed in one critical way. Applicant's argument presupposes the fact that Okamoto tested the

manganese perovskite oxide film of their invention, and determined that films that were thinner/thicker than “several hundred microns” were not suitable.” Applicants respectfully traverse this mischaracterization.

Submitted herewith is a Rule 132 Declaration of Mr. Okamoto, an inventor in the European Patent Application No. EP 0919647A1. Mr. Okamoto’s Declaration establishes the development of the smart radiation device (SRD), and the basis for the teachings in the Okamoto reference that the material should be several hundred microns thick. Submitted with Mr. Okamoto’s Declaration as Exhibit 1 is a contemporaneous publication of the Society of Automotive Engineers that Mr. Okamoto co-authored. Exhibit 1 establishes that it would not have been obvious to one skilled in the art at the time of filing the Okamoto reference to make an SRD layer from 1 to 30 microns thick.

For the foregoing reasons, Applicants respectfully submit that a prima facie case of obviousness has not been made, and even if a prima facie case was made, that the evidence submitted herewith overcomes any case of obviousness made whether prima facie or not. Therefore, the claims presented in the invention patentably distinguish over the prior art of record.

In view of the foregoing, favorable consideration and allowance of the present application is respectfully and earnestly solicited.

Dated: January 20, 2005

Respectfully submitted,

By 

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Application No.: 09/900,771

Docket No.: S2856.0022/P022

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Ichiro Masc et al.

Application No.: 09/900,771

Art Unit: 1773

Filed: July 6, 2001

Examiner: N. J. Uhler

For: **HEAT CONTROL METHOD AND HEAT
CONTROLLER**

DECLARATION UNDER RULE 132

I, Akira Okamoto, hereby declare the following:

1. I am an inventor in European Patent Application No. EP 0919647A1 (the "EP application"), published June 2, 1999.
2. I am also an author of the article attached as Exhibit 1, entitled "Smart Radiation Device: Design of an Intelligent Material with Variable Emittance," Society of Automotive Engineers, Inc. (2001). This article describes the history of the Smart Radiation Device (SRD) since its initial development. The initial development of SRD was the subject of the EP application.
3. At the time of filing the EP application, our development of the SRD was such that we could only form a several hundred micron thick film. Specifically, "[t]he thickness of the SRD, which is initially composed of one material, was 200 um and its weight was about 1.2 kg/m² (SRD1)" (Exhibit 1, under the heading "Lightweight Technology," first paragraph). This statement in Exhibit 1 is consistent with the description of the SRD material in the EP application. As stated in the EP application, the SRD layer "is arranged on the surface 3 of the wall 2 in the form of a several hundred micron thick film" (col. 3, ll. 44-46).

Application No.: 09/900,771

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4. After the EP application was filed, development of SRD devices continued. The objective was to reduce the thickness of SRD1, while retaining its strength and optical properties. As further noted in connection with the next iteration of the material, SRD2, "the thickness of the SRD could be reduced to 70 um and its weight would be about 0.5 kg/m² (SRD2). However it was impossible to reduce the thickness more by grinding because the thin SRD doesn't have enough strength for the grinding process and it isn't easy to handle such a device" (Exhibit 1).

5. Subsequently, progress in the design and manufacturing of the SRD continued. "[B]y changing from the standard ceramic production to the printing technique," the thickness, and thereby the weight, of the SRD was further reduced (Exhibit 1, under the heading "Introduction," fourth paragraph). These changes were neither known nor contemplated when the EP application was filed.

6. When the EP application was filed, it was not known that the SRD could have a thickness of less than 200 microns.

7. Therefore, it would not have been obvious to one skilled in the art at the time of filing the EP application to make an SRD layer from 1 to 30 microns thick.

8. I further declare that all statements made herein are made of my own knowledge and are true except for those statements made on information and belief, which are believed to be true, and further that the statements were made with a knowledge that willful false statements or like so made are punishable but fine or imprisonment, or both, under § 1001 of Title 18 of the United States Code and such willful false statements may jeopardize the validity of this declaration and of any United States patent that this Declaration concerns.

December 27, 2004

Date

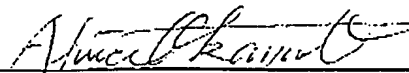
Akira Okamoto



EXHIBIT 1
TO AKIRA OKAMOTO DECLARATION

2001-01-2342

Smart Radiation Device: Design of an Intelligent Material with Variable Emittance

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ABSTRACT

Variable emittance radiator, called SRD, is a thin and light ceramic tile whose infrared emissivity is varied proportionally by its own temperature. Bonded only to the external surface of spacecrafts, it controls the heat radiated to deep space without electrical or mechanical parts such as the thermal louver. By applying this new device for thermal control of spacecrafts, considerable weight and cost reductions can be achieved easily.

In this paper, the new design and the new manufacturing process of the SRD and its optical properties, such as the total hemispherical emittance and the solar absorptance, are described. By introducing this new design and manufacturing process, the weight of the SRD is easily decreased, keeping its strength and the optical properties.

INTRODUCTION

The temperature of spacecrafts is affected by several factors in each respective mission phase. As a result, some technologies have been used for temperature control of spacecrafts. But the thermal control devices presently using conventional techniques are heavy and expensive. Therefore developing a lighter and more economical thermal control device, with high performance, is required.

The SRD can change its optical properties depending on its temperature by its special property of metal-insulator transition. This allows emittance modulation of a spacecrafts' surfaces and components without bulky blinds that have moving parts or electrical instruments that have sensors and wires. The material of the SRD is Sr and Ca substituted LaMnO₃ based perovskites, such as La_{1-x-y}Sr_xCa_yMnO₃ which contains X mol% of Sr and

Y mol% of Ca on La-sites. The SRD was presented for the first time to the 29th ICES Conference in Denver, Colorado, in July 1999. The first publication^[1] describes the principles of the SRD, the optical properties of the materials, La_{0.825}Sr_{0.175}MnO₃ and La_{0.7}Ca_{0.3}MnO₃, and the results of the proton irradiation test for these materials. The second publication^[2] in July 2000 describes the optical properties of the new material, La_{0.775}Sr_{0.115}Ca_{0.11}MnO₃, and the test results of the electron and UV irradiation for the old material, La_{0.825}Sr_{0.175}MnO₃.

Progress in the design and manufacturing process has been made since the last publication. In order to decrease the weight, the SRD production process was improved significantly by changing from the standard ceramic production to the printing technique. This paper describes the advances made during the continuing development activities.

LIGHTWEIGHT TECHNOLOGY

It is very important for space applications to produce light elements with a large proportion of effective surface area used for thermal control. The thickness of the SRD, which is initially composed of one material, was 200μm and its weight was about 1.2kg/m² (SRD1). By grinding the material, the thickness of the SRD could be reduced to 70μm and its weight would be about 0.5kg/m² (SRD2). However it was impossible to reduce the thickness more by grinding because the thin SRD doesn't have enough strength for the grinding process and it isn't easy to handle such a device. SRD2 are sliced from sintered block to ceramic wafers and ground to the required thickness, so the production process is tedious.

These difficulties can be overcome by introducing screen-printing techniques to the production process.

This process is called "Thick Film Process" and the fabrication process is as follows:

1. Ceramic powder is made by using the same method as the standard ceramic production process.
2. The powder is mixed with an organic vehicle that is composed of binder and solvent, and the powder is changed to a paste.
3. The paste is printed on the ZrO_2 substructure by using the screen-printing technique.
4. And then, it is fired at a high temperature (above $1000^\circ C$) for some hours.

This process is used for electronics device, such as chip resistors, ceramic gas sensors and humidity sensors. This method has the advantage that the SRD's thickness can be reduced under $70\mu m$, making the element faster and reducing its weight.

The schematics of the SRDs are shown in Figure 1. Figure 1(a)(b) show conventional SRDs which are composed of one material. In Figure 1(c), a thin ZrO_2 plate that is about $50\mu m$ thick is used as a substructure to reinforce the strength of the thin variable emittance layer. That is to say, it serves as a backbone for the SRD3. So the variable emittance layer on the substructure of the SRD3 is under $20\mu m$. The density of ZrO_2 is equal or a little smaller than the variable emittance material, but it has stronger tenacity. ZrO_2 and $(La,Sr)MnO_3$ are used to make the electrodes and electrolyte in solid oxide fuel cells, so the bonding strength between both materials is enough. As a result, the thickness of the variable emittance material is under one tenth of the old one (SRD1). The SRD3 is thinner and it is also stronger than the SRD2. Table 1 is the comparison of the thickness, the number of layers and the weight for the SRDs.

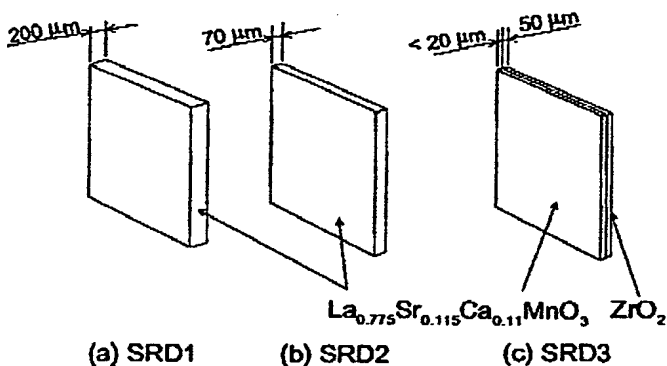


Figure 1. Schematic of SRDs.

Table 1. Comparison of thickness, the number of layers and weight of SRDs.

	SRD1	SRD2	SRD3
Thickness	$200\mu m$	$70\mu m$	$< 70\mu m^*$
Layers	1	1	2
Weight	$1.2kg/m^2$	$0.5kg/m^2$	$< 0.43kg/m^2$

*The thickness of SRD3 includes that of a substructure ($50\mu m$).

In using this "Thick Film Process", it is possible to attach the SRD directly on the surface of the instruments without using adhesive. That is to say, the panel of the instruments is used as the substructure instead of the ZrO_2 plate. Sensitive components of small mass could also be directly covered with the SRD coating to provide even better thermal control. The material suitable for direct application of the coating has to withstand the firing temperature.

EVALUATION OF EFFECTIVE THICKNESS – To work as the thermal control device, the SRD needs enough thickness to avoid transmission of thermal IR. But the thickness has to be minimal to reduce weight of the SRD. In order to evaluate the effective thickness, the spectral transmittance $T(\lambda)$ was calculated. It can be obtained by using the refractive index $n(\lambda)$ and the extinction coefficient $k(\lambda)$ which are calculated from the spectral reflectance $R(\lambda)$ by Kramers-Kronig analysis.^[5] The spectral Reflectance $R(\lambda)$ is measured by using the Fourier transform spectrometer (Bio-Rad FTS-60A/896).

Figure 2 shows the calculated results of the spectral transmittance $T(\lambda)$ on a wavelength region of $1\sim 100\mu m$ of the variable emittance layer for 173K, 293K and 353K. The thickness of the variable emittance layers used for calculation are 1, 5 and $10\mu m$. The transmittance of the $1\mu m$ and $5\mu m$ layer are under 25% and 10% each for wavelength region of $6\sim 100\mu m$. On the other hand, the transmittance of the $10\mu m$ layer is almost 0%. From these results, the effective thickness of the variable emittance layer for the SRD is about $5\sim 10\mu m$.

MEASUREMENT RESULTS OF OPTICAL PROPERTIES

The new SRD (SRD3) is a thin ceramic tile $30\times 30mm^2$ in size, about $59\mu m$ thick and weighs about $355g/m^2$. It is composed of a variable emittance layer and a substructure layer. The material of the variable emittance layer made in this research is $La_{0.775}Sr_{0.115}Ca_{0.11}MnO_3$ and the thickness is $9\mu m$. Figure 3 shows one of the SRD used for the measurement of the optical properties. The cables are thermocouples to measure the temperature and the heater power cables to control the temperature of the SRD. The surface of the materials

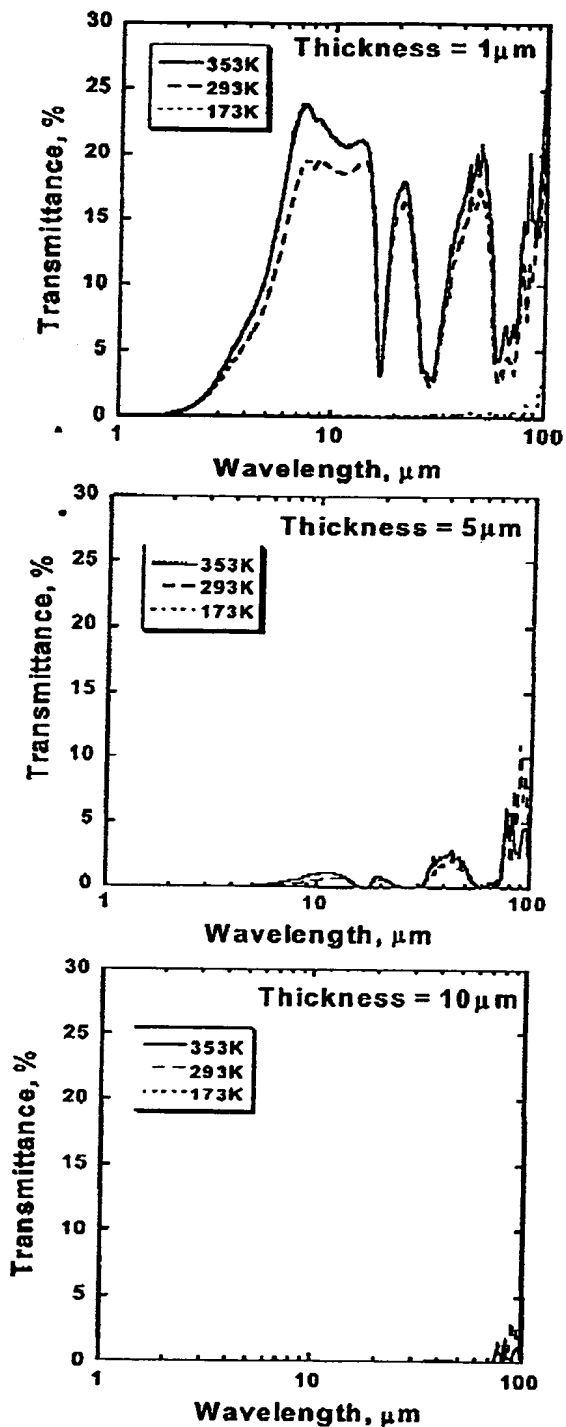


Figure 2. Spectral Transmittance of SRD with 1, 5 and 10 μm thick on a wavelength range of 1–100 μm at 173K, 293K and 353K.

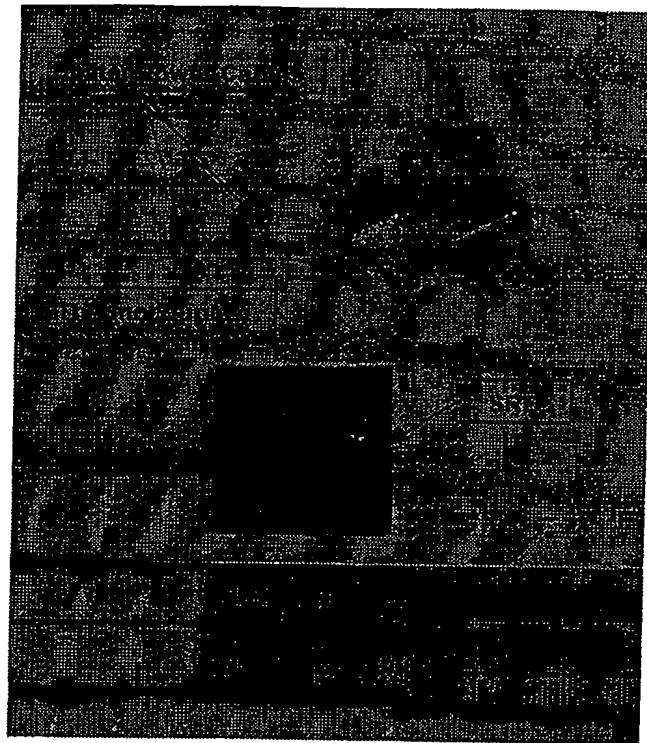


Figure 3. Test piece of SRD.

used for the measurement was left unfinished (i.e., all samples were not polished). Under ideal circumstances, this surface should be polished so that a comparison of optical properties would be more accurate. However, the surface conditions of all samples are practically the same, so the results are not influenced.

The total hemispherical emittance ϵ_H was measured by the calorimetric method⁽⁴⁾ for the temperature range between 173K and 373K, and the solar absorptance α_S was measured spectroscopically with an integrating sphere in the wavelength region of 0.26–2.5 μm .

TOTAL HEMISPHERICAL EMITTANCE - Figure 4 shows the temperature dependence of the total hemispherical emittance for SRD2 and SRD3. The material of SRD2 is the same as that of the variable emittance layer of SRD3. The emissivity of the SRD3 at both high and low temperatures is almost the same as that of the SRD2, and the variation in the emissivity is the same. An overview of their performance is given in Table 2.